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United States Department of the Interior
National Park Service

National Register of Historic Places Multiple Property Documentation Form

This form is for use in documenting multiple property groups relating to one or several historic contexts. See instructions in *Guidelines for Completing National Register Forms* (National Register Bulletin 16). Complete each item by marking "x" in the appropriate box or by entering the requested information. For additional space use continuation sheets (Form 10-900-a). Type all entries.

A. Name of Multiple Property Listing

METAL TRUSS, MASONRY, AND CONCRETE BRIDGES IN VERMONT

B. Associated Historic Contexts

Metal Truss, Masonry, and Concrete Bridges in Vermont

C. Geographical Data

The state of Vermont.

☐ See continuation sheet

D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards for Planning and Evaluation.

Eric Dillenbeck - SHPO
Signature of certifying official

4/12/90
Date

State or Federal agency and bureau

I, hereby, certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

Signature of the Keeper of the National Register

Date

E. Statement of Historic Contexts

Discuss each historic context listed in Section B.

Entire text on continuation sheets.

[X] See continuation sheet

METAL TRUSS, MASONRY, AND CONCRETE BRIDGES IN VERMONT

The history of bridges in Vermont is largely the history of the evolution of public roads and the railroad. Over the course of settlement in Vermont between 1760 and 1830, roads usually evolved from foot and horse paths into rough wagon roads. Between 1790 and 1820 the establishment of postal delivery routes and a number of turnpike companies led to a few well-graded and maintained through-roads. Water transportation along Lake Champlain and the Connecticut River encouraged development of some inter-town routes to the nearest shipping facilities. Most local roads, however, remained under the jurisdiction of district road commissioners in individual towns, and of course the burden of building and maintaining bridges on these roads also fell on local governments. This continued to be the case until the close of the 19th century, when the state established a highway commission to regulate the road system and bridge building in Vermont.

Railroad construction, beginning in 1846 with a line up the Connecticut River to Bellows Falls, did encourage some road construction linking towns to the rail lines, and in many towns a stream or river was bridged to provide a more direct route to the nearest railway depot. Overall, however, the railroads tended to delay major road construction rather than to promote it, though they themselves did undertake ambitious programs of bridge building and rebuilding during the last half of the 19th century and into the 20th.

Since most roadway bridge building in Vermont during the 19th century fell to town governments, they in turn relied on local resources and, to the extent possible, on local expertise. Construction materials were hardly a problem for most of Vermont, with its bounteous quantities of timber and building stone. Timber, a favored material, was used in a number of applications. The simple Kingpost truss, a traditional, medieval European technology, sufficed for crossings of less than about 50 feet; to enhance durability, the trusses often were clad in boards. For longer spans the most common form was a lattice truss, which utilized a web of closely spaced diagonal boards. Lattice trusses were often roofed and clad in boards to protect them from the weather; these are the original covered bridges of Vermont.

The covered bridges in Vermont have a few similarities to metal truss, masonry, and concrete bridges. Like the metal truss, all covered bridges were derived from several wooden truss types, and many used pre-cut standardized members for construction. Although the covering contributed no strength to the structure itself, it did add a picturesque element that is not found in any other bridge type. As in many masonry bridges that were handcrafted by a stone mason, often with identifiable characteristics, the roof, portals, and windows of covered bridges frequently reflect the craftsmanship and stylistic details of a particular builder. Covered bridges were economical to build and required no specialized skill to construct, characteristics shared with concrete bridges.

Masonry construction also took advantage of indigenous materials, but working the stone demanded more time than working timber, and the skill to properly construct a masonry arch was not always present. Vermont's most celebrated bridge mason, James Otis Follett of Windham County, was apparently self-taught. Although Follett worked late in the 19th century, the vernacular technology evident in his bridges accurately reflects the typical stone arch of the entire century. As a result of the apparent limited expertise, stone bridges were far less common than timber. They appear in clusters, such as Follett's work in the Townshend area, which makes up the Follett Stone Arch Bridge Historic District, and the two arches built over Kendron Brook in Woodstock (State Survey #1424-25 and #1424-27) by an unknown artisan. These groupings further indicate that the construction of stone rather than timber bridges in the 19th century depended on the presence of local skilled labor.[2]

Timber and stone also dominated bridge building in the rest of the country until the late 1860s, when iron works began supplying prefabricated truss members according to the designs of the emerging profession of structural engineering. Railroad companies built the first iron bridges, using the designs of their staff engineers. While the railroads fostered innovative work in response to specialized needs, two truss designs had already begun to predominate. The Pratt truss, patented in 1844, and the Warren truss, patented in 1848, offered simplified fabrication and construction because they used a limited number of different members in their webs. They also surpassed other designs in the ability to fully describe the distribution of stresses through mathematical analysis.

The late 1850s and early 1860s saw the introduction of numerous technical improvements that paved the way for prefabricated iron bridges. In 1859 the Lehigh Valley Railroad in Pennsylvania built the first pin-constructed bridge in the United States, which considerably eased construction compared with the use of rivets and bolts, enabling assembly in the field rather than in the shop. The ability to ship unassembled members, rather than large pre-assembled components permitted the erection of iron bridges on roads far distant from rail lines. In the same year the first all wrought-iron bridge went up, a considerable improvement because cast iron was recognized as a brittle material unsuitable for bridges. In 1863 the first all wrought-iron, pin-connected bridge demonstrated the technology that would propel the bridge industry for the next thirty years.[3]

After the Civil War, bridge engineers began their own firms, or joined with iron works, to design, fabricate and market iron bridges for highway use. Even though Pratt and Warren trusses dominated the the field, the 1870s and 1880s were a period of continued experimentation. Some of the new trusses and variants represented a genuine attempt at improvements through greater economy in materials and construction time. C. H. Parker of Boston developed a bowstring truss, which gained some strength from the arch effect of its curved top chord; the c.1870 bridge in Northfield, Vermont (State Survey #1213-85), which once carried Vine Street over the Central Vermont Railroad, is the earliest unaltered example of this important innovation in the state. C. H. Parker later designed a Pratt truss with a curved top chord, creating a pattern that found broad application, and became known as the Parker truss. Other new forms were most important as marketing tools that allowed the firm that held the patent to offer exclusive access to the design. For example, Connecticut's Berlin Iron Bridge Company claimed that its lenticular truss on Town Highway 3 (State Survey #1404-33), which crosses the Second Branch of the White River in East Bethel, Vermont, was cheaper and better than the more common trusses, but its most important selling point was probably its novel appearance.[4]

The fabrication of truss bridges was a capital intensive business that required rail access to be competitive. It was concentrated in the industrial regions of the Northeast and Midwest, mostly in cities. The fabricating shops bought

rolled wrought iron in the shapes of channels, plates and angles, then cut the pieces to the required length and shape, drilled or punched the holes for rivets that connected the pieces of composite members and shipped the entire disassembled bridge to the buyer, by rail as far as possible. No significant fabricator worked in Vermont until the late 1880s, when the Vermont Construction Company of St. Albans was started as a subsidiary of a Springfield, Massachusetts, firm. Relatively poor access to material, equipment and financing, and a lack of a diverse labor pool limited the abilities of Vermonters to participate in this business, ensuring that almost all the metal bridges would be brought from elsewhere. Specific fabricators, contractors, and designers that worked in Vermont are discussed at the end of Section E. A variety of arrangements were made for erecting the bridges on site. Some companies employed full-time erecting crews and moved them around to successive jobs. Others hired crews locally for each job. In many cases the fabricators had no part in the actual construction, but the purchasing town would contract separately for abutment and bridge construction.

Since the state government had no central transportation planning, construction, or maintenance responsibilities until the 1890s, the iron bridge companies sold their wares directly to town governments. Vermont proved a difficult market for most fabricators. Selling in Vermont required long journeys from the centers of production. Most of the fabricators issued advertising circulars periodically, usually featuring engravings of their bridges. Two firms, New York's Groton Bridge and Manufacturing Company and Connecticut's Berlin Iron Bridge Company appear to have supplied many of the bridges in Vermont. Due to their proximity, these firms could afford to send sales agents to the small towns in Vermont, where they exploited every possible advantage in contending for contracts. Despite the best efforts of the sales agents, it appears that no more than two or three hundred iron truss bridges were constructed in Vermont in the 19th century.

Near the end of the 19th century, a specialized form of masonry bridge became popular: the commemorative, monumental arch usually found in town centers. While the masonry bridges built by Follett and other country artisans are more rugged in appearance, the town center bridges have a more formal aspect. The exposed stones have finished surfaces, and the bridge often incorporates decorative elements such as

parapets, railings, and street lights. The town center bridges carried more than horses and wagons. They bore the community's pride in their own permanence and achievement. Metal truss bridges had become associated with the notion of progress, and now a fine masonry arch was seen as making a similarly positive statement about its community. Members of the local elite often contributed to build highly visible stone spans. Often these bridges were named after them, such as the Battell Bridge carrying Route 30 over the Otter Creek in Middlebury (State Survey #0111-50, listed in the National Register as part of the Middlebury Village Historic District, 11/13/1976).

In the last years of the 19th century, Vermont's inadequate roads compelled the state government to take action. Following the lead of New Jersey, which in 1891 pioneered centralized transportation planning and funding, the Vermont legislature in 1892 enacted the first steps that would lead to a state road system and a Highway Commission. By 1898 a Highway Commissioner was in place with the authority to regulate road construction and use.

The relatively light traffic on Vermont's roads and the high cost of even the simplest construction caused the Commission to move very slowly in its first years, building its ties with officials in towns and newly created highway districts, and establishing standards for road width and surface as well as for vehicle use. In establishing priorities for highway expenditure, the Commission started viewing Vermont roads with inter-regional transport in mind. Before long the automobile began to transform this rural state along with the rest of the country. Not only did motor vehicles increase the demand for better roads, they also provided a means to pay for them through road and gas taxes. The Commission was explicitly forbidden to spend state money to build bridges and culverts, but after 1912 was allowed to supply structural engineering services at the request of towns. Finally in 1915 the legislature established a bridge fund, an annual appropriation that the Highway Commission could use to help towns build bridges. In 1917 the federal government initiated funding for road improvements with the Federal Aid Road Act. The federal money was intended to improve mail delivery, and was limited to communities of less than 2,500. All but a handful of Vermont towns qualified, and the state benefitted from annually rising federal allotments.

Along with increasing appropriations came the beginning of government approval and supervision of construction. The State Highway Commission began immediately to impose structural, geometric and alignment standards for bridges once it could enforce them through power of the purse. Federal engineers reviewed every project paid for under the 1917 Road Act. Increased governmental technical participation accompanied rising funding into the mid-1920s. In 1922 the Highway Commission initiated a statewide bridge inspection to allocate maintenance efforts and identify candidates for replacement, and by 1926 they had a full-time staff engineer to supervise the accelerating construction programs.

The broadening of state authority marked the beginning of standardization for Vermont's bridges. Masonry bridges lost favor because the state would not pay for them. Stone bridges of the 20th century invariably were built by town and private funds, usually out of some motivation beyond the technical or the economic. Barre's 1920 granite arch (State Survey #1202-259), for instance, represented the importance of the local quarry industry. The 1915 "Marble Bridge" in Proctor (State Survey #1118-2: 9), actually a concrete bridge with marble facing and detail, was a gift of Mrs. Emily Proctor in memory of Fletcher Proctor, son of the former Vermont governor whose family controlled the quarries. The Highway Commission much preferred concrete over stone. The materials were available throughout the state and the work of building wooden forms or mixing and pouring concrete did not require any rare skill. The Commission alleviated the possible lack of engineering talent in a town by drawing up standard plans for concrete spans and offering them free of charge to the towns. Plans for small culverts were available in 1910, and for bridges in 1915, when the state construction money became available. The 1924 bridge in Hyde Park (State Survey #0805-31) is a good example of the arched concrete spans erected according to the state's specifications.[6]

The cost advantage of concrete over stone was not lost on the towns and cities that undertook their own improvements during this period. For example, the City of Rutland vastly expanded its construction function in the 1920s, resurfacing and extending roads, laying out new ones, and building bridges. Several very simple concrete bridges erected in Rutland under this program include those on Baxter Street (State Survey #1119-83), Granger Street (State Survey #1119-86), and Strongs Avenue (State Survey #1119-87). As a

result of its reasonable cost and ease of construction, concrete bridges had widespread use across the state. In fact, the early-20th century advancements made in the use of concrete, both reinforced and prestressed, in combination with the developing truss technology is, today, the mainstay of our highway system.

The concrete bridges of Vermont escaped complete repetition from site to site. Some towns made commemorative structures out of concrete, much like the more expensive decorative stone spans. The best example, the 1912 Barrett Memorial Bridge (State Survey #0910-52: 59) in South Strafford village, even mimics masonry construction with its inscribed lines in the pattern of the voussoirs of a stone arch, and a raised central tablet in the imitation keystones. The other major deviation from the standard form was the open-spandrel concrete arch, a specialized form used mostly in long spans over deep gorges; by leaving much of the space between the ring of the arch and the roadway open, this form offered substantial economy of material in long crossings. One of the two surviving examples crosses the Winooski River and the Central Vermont Railroad in Colchester (1913, State Survey #0404-38). Vermont's other open spandrel, in Windsor Village (1930, State Survey #1423-29), is much shorter. In this case the decorative appearance of the open spandrel's graceful profile added to its desirability for this central location in the town.

The Commission's greatest impact on truss bridges resulted from its efforts to coordinate new bridge and road construction, affecting alignment, width and other clearances. But factors outside the state's control exerted greater influence, particularly the use of motor vehicles and changes in the fabricating industry. Cars and trucks imposed progressively greater loading on bridges. Over the first twenty-five years of the 20th century, bridges used thicker and heavier members in the effort to keep pace with increased volume and heavier vehicles.

Changes in the bridge-fabricating industry in the late 19th century had begun to narrow the variety in types of trusses. Several bridge failures had made the companies and their designers more conservative in the face of an enraged public. The well-proven patterns--Pratt, Warren and their variants--gained an insurmountable edge. Their relatively simple joints permitted engineers to determine how the load was distributed in them, and to design with the assurance

that any failure would come within a member and not a joint. The consequent tendency to make the members larger contributed to the increasing heaviness of the trusses. The industry also adopted steel as the favored material. The first all steel bridge in the United States went up in 1879 on the Chicago and Alton Railway, but engineers and fabricators distrusted steel, particularly for tension members, until the perfection of the open-hearth process of steel production around 1890. By that time, the common structural shapes (plates, channels and angles) were available in steel at prices comparable to wrought iron. The final important technical change came in the means of assembling bridges in the field. Pinned connections had been favored for their ease of assembly, even though engineers realized that riveted connections provided superior rigidity. Late in the 19th century, innovations in pneumatic field riveting overcame the cost advantage of pinned joints, and riveting became standard.[8]

Economic consolidation in the fabricating industry solidified the technical changes that occurred. In a classic case of market dominance through financial manipulation, the banker J. P. Morgan in 1900 formed the American Bridge Company. In its first year American Bridge purchased 24 bridge companies, representing half of the nations fabricating capacity, and made further acquisitions in 1901 and 1902. In 1901 American Bridge was itself purchased by U.S. Steel, the largest producer of structural steel. This combination of the leaders in both primary and secondary production achieved immediate control of the bridge market, leaving survivors to fight over scraps from the giant's table. The firms that had previously fabricated most of the metal bridges in Vermont, Berlin Iron Bridge and Groton Bridge and Manufacturing, were both among the first 24 absorbed by American Bridge. In a pattern repeated frequently, executives of the two acquired companies left American Bridge after a short time and started smaller competing shops in their home areas: Berlin Construction Company and Groton Bridge Company. Like the rest of the small firms, Berlin and Groton resigned themselves to compete in regional markets by capitalizing on their greater knowledge and contacts in their areas, as well as whatever incremental cost advantage in transportation they could offer over American Bridge. The strategy of competing by offering innovative designs disappeared, and as the 20th century opened, the steel, rivet-connected bridge using a Pratt or Warren truss, or one of their variants, was clearly dominant. By 1910 the industry's inventories of wrought iron and of

members suitable for pinning had been used up[9] and riveted steel trusses achieved universal application.

From its inception, American Bridge was very successful in Vermont. From 1900 to 1914, while American slowly reorganized its massive holdings, it undertook numerous joint contracts with United Construction of Albany, New York, with United responsible for the sales effort and bridge erection. After 1914 American Bridge sold directly; erection was either contracted for separately by the purchaser or subcontracted by American. A few smaller firms managed to win occasional contracts in Vermont but, to judge from the surviving structures, the only serious challenge to American Bridge came from Berlin Construction Company, and only then as part of the massive rebuilding effort after the 1927 flood.

Thus in the first quarter of the 20th century a number of forces converged to result in the beginnings of standardization among bridges in Vermont. Masonry became increasingly rare. The plans offered by the Highway Commission encouraged standardization for concrete bridges. The Commission determined many characteristics of truss bridges according to the needs of a comprehensive state road system. Meanwhile, growing conservatism among bridge designers, technological changes in bridge construction, and economic consolidation of the bridge industry all tended to limit experimentation and to promote a narrow range of technical options. These factors acted nationwide, not just in Vermont. But in rebuilding after the great flood of 1927, Vermont would achieve a degree of standardization far in advance of other states.

On November 3 and 4, 1927, record rainfall devastated northern New England. Climaxing a wet autumn that had filled the reservoirs and the absorption capacity of the soil, the rain swelled brooks into rivers and rivers into raging torrents.[10] Approximately four billion tons of rain flooded the state. The heaviest rain was recorded in Vermont's Winooski Valley, some 9.5 inches in 24 hours. Two billion cubic feet of rain fell on the 1000 square miles that make up the Winooski basin, enough water to supply the 1927 population of New York City for three months.[11] The Cavendish Gorge, which is a half a mile long and as much as 100 feet deep and 600 feet wide, was created by flood water moving two million tons of earth in one night.[12] But no part of Vermont escaped the flooding, and the valleys of Otter Creek, the White River, the Ottaquechee, Passumpsic, Lamoille and Missisquoi Rivers all suffered serious property damage. Statewide, more than

1,200 bridges were washed away.[13]

With all the in-state communications disrupted, it took several weeks to even estimate the damage. Once the magnitude of damage to roads and bridges was clear, the Governor supported Vermont's first use of public debt for transportation development, and by the end of November the legislature authorized $8 million in bond funding for rebuilding roads and bridges.[14] This funding centralized power in Montpelier, the capitol, and increased the state's control over road and bridge building that traditionally had been supervised by individual towns.[15]

The state, however, could not complete such a massive effort by itself, and the Governor did not object when the United States Congress appropriated more than 2.6 million dollars for rebuilding bridges. The District Federal Office of the Department of Transportation sent 14 survey crews to help assess the damage and begin plans for reconstruction, the majority of which took place between 1928 and 1930. Prior to the flood the Highway Commission's Bridge Department included one engineer and 12 draftsmen, most of them temporary summer help. As soon as the surveys were completed the department grew to 35: 3 engineers designing steel structures, 4 designing concrete, 26 draftsmen and 2 engineering technicians. Of utmost interest in terms of the structures that resulted, American Bridge Company loaned the agency a structural engineer to head the team designing steel structures. The other two steel designers came on temporary loan from the federal government.

Because of the enormity of the work it was decided to standardized as much work as possible. Standard slab spans were designed at one-foot intervals between 4 and 20 feet in length, T-beam spans at five-foot intervals between 25 and 55 feet, and I-beam spans at five-foot intervals between 25 and 70 feet. Options for all these types included open and solid rails, sidewalks, and varying widths of road. Standard abutments were designed at increments of two feet in height up to 20 feet, and for square skews as well as standard variations of 15, 30 and 45 degrees.[16]

Standard steel trusses came in increments of 10 feet in length between 60 and 100 feet, and of 20 feet for spans longer than 100 feet. The bridges under 100 feet were Warren pony trusses. The principal variation came in the steel top chord. Most of the bridges featured a straight

top chord parallel to the bottom chord (such as Fairfax, State Survey #0604-63). But for locations of heavier traffic, such as town centers or major through roads, the standard design called for a curved, polygonal top chord; examples include the bridges on Langdon and School streets in Montpelier (State Survey #1211-197 and #1211-198), and Route 100-C in Hyde Park (State Survey #0805-22). Between 100 and 160 feet in length, the standard was a Pratt through truss, although some overlap existed with the Warren pony trusses at the lower end; the typical Pratt truss can be seen carrying Town Highway 6 over the Missisquoi River in East Highgate (State Survey #0609-19). Above 160 feet the engineers specified a Parker truss, the polygonal top chord variant of the Pratt truss, as seen on Town Highway 3 in Jonesville, Richmond (State Survey #0411-32).

Over 1,600 bridges were built by the end of 1930.[17] The standard plans, including beam and slab designs, accounted for about 75 percent of the new bridges constructed, and the great majority of the remaining crossings consisted of some combination of standard spans. Only very few crossings required specialized design effort, the most notable being the "Checkered House" bridge in Richmond (State Survey #0411-18), a Pennsylvania truss that was the longest single span erected under the reconstruction program. All the truss bridges had a roadway width of about 21 feet. The most difficult fit between the standard plans and the actual conditions was in the alignments, since the standards permitted only limited variations of skew. In addition, for speed of reconstruction the engineers decided in many places just to cap the existing abutments with concrete and built the new bridge on the old alignment. As a result, many of the flood-era bridges that stand today are approached on tightly curving roads that do not meet modern standards.[18]

The individual members of the standard trusses differed from the common practice evident before the flood. Pre-flood bridges virtually all featured "built-up" members: various combinations of plates, channels and angles connected with rivets. The flood trusses used this technique for their top and bottom chords, but vertical and diagonal members between the chords were usually rolled I-beams that required no assembly. The obvious advantage to such members was to speed reconstruction by minimizing shop time. They probably cost less than built-up members as well. The prior reluctance to use rolled members (on a nationwide basis, not just in Vermont) was based on the greater resistance to

twisting offered by built-up members. The horizontal stiffeners spanning the middle panels of the through trusses built after the flood helped to alleviate this problem. Furthermore, the presence of an American Bridge engineer gave the Highway Commission unprecedented access to expert advice on the availability and strength of various material, particularly since U.S. Steel, the parent firm of American Bridge, ranked as the foremost source for rolled structural steel. The Vermont trusses built in 1928, 1929, and 1930, during the flood reconstruction program, had some national impact among bridge engineers. Before the flood, the steel industry had been improving its rolling technology and structural engineers had been moving toward the more simple made rolled members. The intensive design and construction effort following Vermont's 1927 tragedy provided a massive laboratory to test the efficacy of rolled members. In 1929, for the first time the American Association of Highway Officials "Standard Specifications for Highway Bridges" recommended all rolled sections for truss webs, and at least one engineering textbook was illustrated with examples from Vermont's reconstruction program.[19]

The vast extent of the reconstruction program strained not only the resources of the public agencies that took part, but also the private firms that stood to benefit from the massive surge in contract awards. American Bridge and a handful of other companies contributed to the reconstruction program, but many did not stay in the bridge business after the crisis had passed.

The flood reconstruction program, with its special funding and centralized engineering, put the Highway Commission a decade ahead of schedule and created a better road system than had existed before the flood. The program brought a systematic upgrading of older roads and construction of bridges that the Highway Commission had pursued on a piecemeal basis before the flood.

The prolonged economic crisis of the 1930s brought a virtual halt to locally sponsored transportation improvements. All new construction used state or federal funds that were channeled through the Highway Commission. State appropriations did nct increase significantly, but Vermont received substantial federal money for roads and bridges under various New Deal programs. Federal participation institutionalized the bridge design standards, which had evolved during the flood recovery program, and began the intimate federal

oversight of the road system that still exists. The Highway Commission used the standardized designs from the flood reconstruction program for the truss and concrete bridges that went up after 1930 under all these programs. In fact, bridges constructed today rely on and use the same technology that was developed in the early part of this century and put into practice during the reconstruction program.

The final chapter in the technical evolution of Vermont's bridges started during World War II. As a critical strategic material, steel was subject to strict wartime allocation limitations. After the first successful demonstration of prestressed concrete in 1942, that material offered one solution to the steel shortage. It found greater application in the western states, where the steel makers did not control the bridge industry as tightly as they did in the east. The steel firms' preferred course was to design a steel bridge sufficiently economical of material that would not hamper the war effort. The ability to increase the size of rolling-mill machinery, and its products, offered the solution: deep steel beams supported on concrete piers. After the war, bridges continued to be designed with economy of material and ease of construction in mind. Through weight of approval, government officials established the steel beam on concrete pier bridge as the national standard, a role it continues to play today.[20]

NOTES:

Most of this context is based on the bridge survey conducted for the Division for Historic Preservation by Historic Resources Consultants of Hartford, Connecticut. Historic Resources Consultants, "Vermont Historic Bridge Survey: Final Report and Preservation Plan," (typewritten manuscript, 1985).

[1]Vermont Division for Historic Preservation, Curtis B. Johnson and Elsa Gilbertson, eds., The Historic Architecture of Rutland County, (Montpelier, Vt., 1988): 22-23.

[2]See the thematic National Register nomination on Follett's bridges in the file of the Vermont Division for Historic Preservation.

[3]J. A. L. Waddell, Bridge Engineering, (New York: John Wiley and Sons, 2 vols., 1916): I, 23-29; Donald C. Jackson and Allen Comp, "Bridge Truss Types," History News 32, no. 5 (May 1977): unpaginated; Donald C. Jackson, "Railroads, Truss Bridges and the Rise of the Civil Engineer," Civil Engineering (October 1977): 97-101.

[4]Waddell, I, 29; Jackson and Comp.

[5]Vermont Highway Commission, Biennial Report, 1908, 5-12; 1910, 7; 1914, 11; 1916, 5-6; 1918, 7-10; 1922, 10.

[6]Vermont Highway Commission, Biennial Report, 1910, 27; 1916, 5-6; 1924, 9, shows the 1924 immediately after construction.

[7]Bryan VanSweden, "Concrete Bridge Preservation," an unpublished paper on file at the Vermont Division for Historic Preservation (1987): 1.

[8]Jackson; Waddell, I, 24-28; Charles M. Fowler, "Machinery in Bridge Erection," Cassier's Magazine 17 (February 1900): 327-344.

[9]Victor C. Darnell, "Lenticular Truss Bridges from East Berlin, Connecticut," Directory, The Journal of the Society for Industrial Archeology 5 (1979): 3, 38, 85-86.

[10]Arthur F. Stone, The Vermont of Today, (Lewis Historical Publishing Company, Inc., 4 vols., 1929): I, 163.

[11]Ibid., 162.

[12]Ibid., 168.

[13]A considerable body of literature has poured forth regarding the 1927 flood. For a sampling of the national coverage of the disaster see "Record Rainfall Causes Heavy Damage in New England States," Engineering News-Record, 99 (November 10, 1927): 770-773 and Patrick E. Purcell, "The Flood of '27: The Factual Story of a Disaster in Vermont," National Railway Bulletin, 42, no. 6 (1977): 4-10, 46. For descriptions of the devastation in various areas of the state see Harold H. Chadwick, "Flood," Vermont Life, 7 (August 1952): 8-13; Jerome E. Kelley, "Flood! Vivid Memories of the 1927 Catastrophe," Vermont Life, 32 (August 1977): 30-35; J. M. French, "The Flood of 1927 in Lamoille Valley," Vermonter, 35 (March 1930): 56-60; "The Flood of 1927 in Orleans County," Vermonter, 33 (January 1928): 9-20; Rose L. Kent, "Flood-tides of Bennington," Vermonter, 33 (April 1928): 55-62; "The Flood at Rutland," Vermonter, 33 (May 1928): 70-76; Georgia White, "The Rebellion of 'The Long River,'" Vermonter, 33 (June 1928): 86-93.

[14]Vermont Highway Commission, Biennial Report, 1930, 7-8.

[15]The University of Vermont, Jennie G. Versteeg, ed., Lake Champlain: Reflections on Our Past, (Burlington, Vt., 1987): 25.

[16]"Reconstruction of Vermont Highways," Journal of the Boston Society of Civil Engineers, 15, no. 10 (December 1928): 449-466.

[17]Stone, The Vermont of Today, II, 704-705.

[18]"Reconstruction of Vermont Highways," Journal of the Boston Society of Civil Engineers, 15, no. 10 (December 1928): 460-461.

[19]Standards cited in Leonard C. Urquhart and Charles E. O'Rourke, Design of Steel Structures, (New York: McGraw-Hill, 1930): 120; this same volume contains the illustrations of Vermont bridges.

[20]David A. Simmons, "Ohio Bridges from 1850 to 1950: Reflections of Society," delivered at the Conference of the Society for Industrial Archeology, 1985, unpaginated transcript courtesy of the author.

KNOWN BRIDGE FABRICATORS, CONTRACTORS, AND DESIGNERS

AMERICAN BRIDGE COMPANY

American Bridge Co. presents a classic example of the monopolistc practices of big business at the turn of the century. J.P. Morgan, the capitalist's capitalist, incorporated American Bridge in 1900. The company lasted barely a year as an independent entity, because United States Steel Co. bought most of the stock of the new firm and operated it as a subsidiary. In its first year American Bridge purchased twenty-four companies, representing fully one-half of the nation's fabricating capacity at the time. Eight of the purchased firms were in New York, and they operated under the umbrella organization known as Empire Bridge Co., a subsidiary of American. Another subsidiary, American Bridge Co. of New York, was responsible for all sales and contracts. American Bridge of New York also took charge of erection, unless another building firm won the job in its own right and simply ordered the steel from American. American Bridge opened a new fabricating plant in Ambridge, Pennsylvania, in 1903, and began decommissioning the older plants of the purchased firms. The new plant was by far the largest in the country, three times bigger than the prior record-holder.

Until a major corporate reorganization in 1914, much of American Bridge's work in Vermont came through United Construction Co., a nominally independent contracting firm based in Albany, New York. After 1914 the number of joint contracts between the two firms diminished, although later examples exist, notably the "Power Plant" bridge built in 1926 in Essex Junction.

American Bridge pursued a policy of total market dominance, bidding on any work in any state as long as it involved steel bridges. Its massive resources and national scope drastically altered the competitive situation in the nation's bridge industry. Innovative designs had already lost much of their marketing appeal in the late 19th century, due to several well-publicized disasters that led engineers to rely on the simple, tried-and-true truss patterns. American Bridge was the final knell for non-standard trusses because even if an innovative design had some intrinsic appeal, the economic position of

American Bridge would usually win anyway. The smaller firms that stayed in business waged their competition along economic lines, attempting to underbid American while offering essentially the same product. The smaller firms generally did not compete nationwide, but only in their home regions.

Vermont's bridges illustrate clearly the success of American Bridge. The state was remote from most of the nation's bridge makers, who were concentrated in the Midwest, but American could afford to absorb the additional transportation costs to do business in Vermont. Only Berlin Construction Co. was able to compete with Amefican in Vermont; its Connecticut plant was about the same distance from the state as American's fabricating facilities in New York. After the New York plants were closed down, the extra trnsportation from Ambridge was hardly an obstacle to American's continued presence in Vermont. American Bridge is still in business today as the nation's largest structural fabricator.

References: Victor C. Darnell, Directory of American Bridge-Building Companies, 1840-1900 (Washington, D.C.: Society for Industrial Archeology, 1984), 77-81, 85-86; R.A. Talbot, American Bridge Company, History and Organization (Pittsburgh: privately published, 1975): 16-18.

BERLIN CONSTRUCTION COMPANY

When American Bridge Co. acquired Berlin Iron Bridge Co., three officers of the Berlin firm left to start their own concern, capitalizing on their extensive contacts in the New England market. In 1902 the new company, Berlin Construction Co., built fabrication shops in the village of Kensington, town of Berlin, some four miles distant from the site of their former plant. Until World War II, Berlin Construction played a significant role in the regional bridge market, selling numerous spans throughout Connecticut, western Massachusetts, and Vermont. Harry Collins (see entry below for H.L. Norton) ran a Berlin Construction sales office in Springfield, Massachusetts, covering much of northern New England. In Vermont and Connecticut, Berlin Construction constituted the principal competition to American Bridge, the national leader in the field. After the war, Berlin Construction turned more to structural fabrication and erection for buildings. Still in business today under the name Berlin Steel Construction Co., the firm no longer makes bridges.

References: Darnell, Directory, 3; Matthew Roth, Connecticut: An Inventory of Historic Engineering and Industrial Sites (Washington, D.C.: Historic American Engineering Record, 1981), 69-70.

BERLIN IRON BRIDGE COMPANY

Berlin Iron Bridge Co. was formed in 1883 from the Corrugated Metal Co., which had produced shutters, shingles and roofs of rolled iron. The firm had moved into fabrication of structural iron, such as roof trusses, as a corollary to its main business, and found the structural work accounting for an increasing portion of sales. In the late 1870s Corrugated Metal acquired the rights to William Douglas' recent patent for a parabolic truss, and bridge work soon became the firm's sole pursuit, as reflected in the 1883 name change. Berlin Iron Bridge built hundreds of its distinctive parabolic, or lenticular, trusses in the 1880s and 1890s, and grew to become the largest structural fabricator in New England. The firm also erected a smaller number of bridges in more standard configurations, such as Pratt and Warren trusses and plate-girder spans. The distinctive Berlin lenticular truss was sold to communities as far away as San Antonio, Texas, but the great majority of sales were in the Northeast. When American Bridge Co. was formed in 1900, Berlin Iron Bridge Co. was one of its initial acquisitions. American Bridge dismantled the East Berlin factories and moved the buildings to a new plant in Pennsylvania.

References: Darnell, Directory, 3-5; Victor C. Darnell, "Lenticular Bridges from East Berlin, Connecticut," IA: The Journal of the Society for Industrial Archeology 5 (1979): 19-32; Roth, 69-69.

BETHLEHEM STEEL COMPANY

Bethlehem Steel Company originated in northeastern Pennsylvania as a producer of rails. By the early 1890s, having failed to achieve success in the very competitive rail market, Bethlehem turned to heavy forgings that went into ordnance. The chief engineer, John Fritz, urged the company to diversify into production of structural steel, but his suggestions went unheeded until the early years of the 20th century, when Charles Schwab was brought in from U.S. Steel to run Bethlehem. Schwab not only

devoted substantial capacity at the home plant, in Bethlehem, Pennsylvania, to structural fabrication, but he also opened a new plant in Buffalo, New York, that performed structural work as part of its activities. Bethlehem expended its structural capacity in 1922 with the acquisition of Lackwanna Bridge Works, another Buffalo-area fabricator. Bethlehem is still in business as a steel producer.

References: Interview with Thomas E. Leary, Curator, Buffalo and Erie County Historical Society, September 1985..

BOSTON BRIDGE WORKS

D.H. Andrews founded Boston Bridge Works in 1876. In the late 19th century this firm ranked second in New England to Berlin Iron Bridge Co. in structural-fabrication capacity. The two firms did not often compete directly, because Berlin built mostly highway bridges while Boston Bridge built mostly for railroads. Boston Bridge's market was truly national in scope, numbering many western railroads among its customers. Movable bridges were a specialty, and its products also included railroad turntables and roof trusses. Boston Bridge escaped absorption into American Bridge Co., and even grew by about 50 percent in fabrication capacity during the early years of competition with American Bridge. The firm lasted until 1930.

References: Darnell, Directory, 22-23; Boston Directory, 1876-1931.

M.J. BURRINGTON, JR.

Burrington's principal business was consulting work as a civil engineer. His career spanned from about 1910 to 1950, and he was based in Bennington for the entire period. Since the Bennington area (like much of Vermont) had relatively infrequent need for professional engineering, Burrington also pursued related activities. Around 1920 he ran a construction company with E.L. Lambert, in addition to his engineering firm; Lambert & Burrington in turn made a sideline of selling bulk building materials such as lime, cement, and plaster. Bridges apparently constituted a small portion of Burrington's activity. Only one reinforced-concrete bridge is known to have been built by his firm. After the 1927 flood, when the massive reconstruction program provided opportunities for many firms that did not

normally pursue bridge construction, Burrington sub-contracted to Berlin Construction Co., probably for work on abutments.

References: Bennington Directory, 1916-1946.

J.E. CASHMAN, INC.

In the early 20th century, J.E. Cashman, Inc., was among the largest construction, teamster and warehouse firms in Burlington, Vermont. Principal owner was Burlington native James E. Cashman. The company's building business primarily involved foundations and other sub-structural work, including diving and underwater construction; bridge abutments were a specialty. Cashman also rented out construction equipment, such as derricks and pile drivers, and operated two warehouses, one at the corner of College and Champlain streets and one along the railroad at the foot of King Street. Cashman acted as a sub-contractor for fabricating firms that won bridge jobs during the reconstruction following the 1927 flood. Both Berlin Construction and Bethlehem Steel used Cashman for sub-structural work.

References: Burlington Directory, 1920.

CANTON BRIDGE COMPANY

Canton Bridge Co., of Canton, Ohio, began business in 1876 but apparently did not pursue work outside of its immediate region until after a new infusion of capital pursuant to the firm's incorporation in 1891. Like other Midwestern bridge builders, Canton must have found Vermont to be a difficult business environment: remote and sparsely populated, the state was also much easier to work in for the major bridge firms from New England and eastern New York. Two Canton bridges remain in Vermont, one that probably dates from c.1900 and one from 1914. In 1929 the firm was absorbed by the Masillon Steel Co., also of Ohio.

References: Darnell, Directory, 48; The Ohio Historic Bridge Inventory, Evaluation and Preservation Plan (Columbus: Ohio Department of Transportation, 1983), 222.

GROTON BRIDGE AND MANUFACTURING COMPANY/GROTON BRIDGE COMPANY

This firm was founded in 1877 as the Groton Iron Bridge Company, taking its name from the New York town it was located in. The product lines expanded to include punches, straightening machinery (both used in bridge fabrication) and woodworking machinery, and in 1887 the company added "Manufacturing" to its name to reflect the change. In the 1880s and 1890s, Groton vied primarily with Berlin Iron Bridge Company for contracts to build highway bridges for towns in Vermont. The two firms were both large enough to offer the most competitive pricing for bridge work, and both were approximately equidistant from Vermont. Groton Bridge and Manufacturing was one of the firms acquired by American Bridge Co. upon its founding in 1900. The former owners of Groton bought their company back a year later and operated at about two-thirds of former capacity under the name of Groton Bridge Co.

References: Darnell, Directory, 38, 79, 85.

H.L. HAUSER BUILDING COMPANY

Hauser was a Boston contracting firm specializing in reinforced-concrete construction. The firm advertised its specialty as foundations for buildings, machinery and tanks. Its participation in Vermont bridge building was tied directly to the extraordinary needs of the reconstruction program following the 1927 flood. The great number of bridges taxed the capabilities of the firms that built most of the state's bridges before the flood, opening opportunities for other fabricators. One of these was Bethlehem Steel, whose only bridges in Vermont went up between 1928 and 1930. Bethlehem relied on New England construction firms for sub-structural and erection work, and Hauser was one of the regional sub-contractors to work with Bethlehem.

References: Boston Directory, 1925-1930.

KITTREDGE BRIDGE COMPANY

Kittredge Bridge Co. was a construction firm based in Concord, New Hampshire, headed by Arthur H. Kittredge. Kittredge ran the bridge department for the Colburn Construction Co., also of Concord, before beginning his own firm in the early 1920s. It

appears that Kittredge may have taken over the Colburn business and changed its name. Kittredge Bridge, like so many others, benefited from the enormous demand of the 1928-30 reconstruction program, winning a contract to construct a span fabricated by American Bridge Co. The firm, also like many others, did not survive the 1930s.

References: Concord City Directory, 1915-1935.

LACKAWANNA BRIDGE WORKS

Known variously as Lackawanna Bridge Works, Lackawanna Steel Construction, and Lackawanna Steel, this company operated in the early 20th century in the Buffalo, New York, area. The firm originated in Scranton, Pennsylvania in the 1840s, as an iron-smelter, and in the 1870s it added the Bessemer process to produce steel rails. In 1901 William Scranton, then head of Lackawanna, moved the company to West Seneca, New York, outside of Buffalo, in response to the entreaties of Buffalo promoters who wanted to establish heavy industry in their region. (Part of West Seneca was incorporated in 1911 as the new town of Lackawanna, reflecting the influence of the steel producer.) Bethlehem Steel, which also had major facilities in the Buffalo area, bought Lackawanna in 1922. The only Lackawanna bridge in this study bears the date 1922, so the bridge represents the company's final year of independent operation.

References: Leary interview.

A.B. LANE

Adolph B. Lane, active in the 1920s and 1930s, controlled several businesses in his home city of Barre--a lumber company, a water company, and a general contracting company. His construction company apparently did very little bridge work; the only known example is the contracting work for the "Power Plant Bridge" on Route 2A in Essex Junction, which Lane shared with United Construction Co. of Albany, a much larger firm. Lane's background and connections would have suggested greater participation in state road-building, because two of his relatives worked for the state: Alfred W. Lane, a soils engineer for the highway department, and Gordon M. Lane, an engineer.

References: Barre City Directory, 1920-1940.

McCLINTIC-MARSHALL COMPANY

This firm, based in Pennsylvania, was started around 1901 by former executives of companies absorbed by American Bridge Co. in 1900. Several new firms, notably Berlin Construction Co., were started at that time as executives from formerly independent bridge companies either left American Bridge or were let go as a consequence of consolidating operations. McClintic-Marshall's ambitious marketing plan included the opening of regional offices throughout the country in the attempt to challenge the national role of American Bridge. The firm had achieved a foothold in northern New England by the mid-1920s (they built at least one bridge in Vermont before the 1927 flood, the Route 100 span in Morrisville), just in time to benefit from the enormous amount of rebuilding work after the flood. Bethlehem Steel absorbed McClintic-Marshall in 1930.

References: Interview with Donald C. Jackson, National Musuem of American History, September 1985.

McINTOSH AND CRANDALL

This Burlington-based company was a partnership between Herbert M. McIntosh and Frank H. Crandall. Early in the 20th century, both worked for the city of Burlington, McIntosh as the city engineer and surveyor and Crandall as the superintendent of the water supply system. By 1916 they had left the city's employ to operate their own consulting engineering firm, advertising their specialties as road, sewer and water works design. The firm designed one bridge in the survey, the concrete arch carrying Park Street in Springfield.

References: Burlington City Directory, 1902-1930.

NATIONAL BRIDGE AND IRON WORKS

This firm, established in 1868 by the Boston partnership of Blodgett and Curry, was among the first independent bridge fabricators in the country. Before the late 1860s, design and fabrication of truss bridges had fallen exclusively to the railroads. C.H. Parker served as consulting engineer to the firm, and his patented design for a curved-chord truss was the basis for much of National Bridge's business. Like any new

industrial sector, the independent bridge makers experienced considerable uncertainty in their early years, and most of the companies had only the most ephemeral of tenures in the trade, including National Bridge. It was out of business by 1875. The firm was highly significant, however, for its association with Parker, who went on to develop the curved-chord variation of the standard Pratt truss. Known as the Parker truss, this pattern was widely used for long-span highway bridges until the very end of the truss-bridge era. Parker's early career is almost wholly undocumented with standing structures, making the c.1870 Parker Patent span built by National Bridge a civil engineering landmark of national importance.

References: Darnell, Directory, 23-24.

C.F. NEWTON CONSTRUCTION COMPANY

Cheney F. Newton, of Springfield, Massachusetts, was a carpenter who ran a small operation out of his home in the early 1920s. Later in the decade he had built his business into a medium-sized contracting company, in time to capitalize on the extensive contracts let in the aftermath of the 1927 flood. Newton was one of several independent contractors who worked on bridges fabricated by Berlin Construction Co. The Newton firm probably built the abutments and provided erection crews for two of Berlin's flood-era bridges, both in Hyde Park, Lamoille County.

References: Springfield City Directory, 1920-1930.

HENRY L. NORTON

Henry L. Norton was a West Springfield resident who learned the bridge business in the 1890s, while in the employ of R.H. Hawkins Iron Works (see entry below for Vermont Construction Co.). Around 1900 Norton set up a competing firm, Norton and Collins Co., with partner Harry Collins. The business did not last more than a few years, and for several more years Norton operated on his own before opening the bronze foundry that occupied him for the rest of his life. Collins went on to run the Springfield sales office of Berlin Construction Co. It is unlikely that Norton produced more than several dozen bridges; only one standing structure in Vermont is known to be his work. The lone Norton bridge, in Cavendish, was archaic even in its day, especially in its use of pinned connections.

References: Norton obituary, Springfield Daily Republican, March 23, 1932; Springfield City Directory, 1903.

GERALD B. OWENS

Owens ran an eponymously named construction company in Springfield, Massachusetts, during the first third of the 20th century. Bridges were apparently not a specialty, but familiarity with concrete construction enabled Owens to bid on bridges of that material. The only example in the survey of the company's work is the open-spandrel reinforced-concrete arch in Windsor.

References: Springfield City Directory, 1905-1935.

PALMER STEEL COMPANY

Palmer Steel Co. was active as a bridge-builder in the middle and late 1920s, fortuitous timing because it coincided with the great post-flood reconstruction program in Vermont. It is unclear in the available records whether Palmer fabricated its own steel or simply ordered fabricated stock and took charge of erecting the structures. In 1924, Palmer Steel shared a Springfield address with one of the firms descended from R.F. Hawkins Iron Works, suggesting that Palmer may have been involved with this major fabricating concern. Palmer Steel did not survive the Depression.

References: Springfield City Directory, 1920-1935.

PITTSBURGH-DES MOINES STEEL COMPANY

This firm appears to have begun around 1901, the first year it advertised in national trade journals. Pittsburgh-Des Moines specialized in water towers, but its experience translated well to bridge work (a relatively minor portion of the business) because water-tower trestles consisted of built-up girders or rolled I-sections whose fabrication and erection was fundamentally similar to bridge building. The firm apparently made some attempt to market bridges in New England in the mid-1920s, and sold at least one bridge in Vermont before the 1927 flood. Its other Vermont bridge was part of the post-flood

reconstruction program.

References: Jackson interview.

STANDARD ENGINEERING AND CONTRACTING COMPANY

This Toledo, Ohio, firm lasted about twenty years after its incorporation in 1918. It was one of a half-dozen fabricators that made Toledo a center of bridge construction in this period. Standard's chief engineer, Claude Ramsey, had worked for one of Toledo's largest producers, Wincoop and McGormley before joining Standard. Standard apparently made limited sales in the eastern states, and only a single example of the firm's work is found in Vermont today.

References: Ohio Preservation Plan, 221; Toledo City Directory, 1915-1935, courtesy David Simmons, Ohio Historic Preservation Office.

JOHN W. STORRS/STORRS AND STORRS

John W. Storrs was born in Montpelier but his family moved to Concord, New Hampshire in the early 1870s, when Storrs was a boy, and he spent the rest of his life there. Storrs started his long career in structural engineering in the 1890s, as a bridge engineer for the Boston and Maine Railroad. In 1903 he began simultaneously to serve as the state engineer for Carroll, Coos and Grafton counties, New Hampshire. Storrs and his son, Edward D., opened their own engineering consulting firm in 1906, a firm that designed several of the notable bridges in this state, such as the steel arch over Quechee Gorge, the masonry arch bridge in Barre, and the Route 119 bridge over the Connecticut River in Brattleboro. The busy father-son team also ran the Ford Foundry in Concord, John as president and Edward as superintendent.

References: "Concord's 150th Anniversary," Granite Monthly 47 (May-June 1915); E.D. Storrs and J.W. Storrs, Storrs: A Handbook for the Use of Those Interested in the Construction of Short Span Bridges (Concord: by the firm, 1918); Concord City Directory, 1911.

UNITED CONSTRUCTION COMPANY--See entry for American Bridge Company.

VERMONT CONSTRUCTION COMPANY

Vermont's only significant 19th-century bridge fabricator, Vermont Construction Co., was a subsidiary of R.F. Hawkins Iron Works of Springfield, Massachusetts. Hawkins Iron Works could trace its origin to the very beginning of the bridge-building business in the United States, through an unbroken chain of succession (including ten differently named firms) to the 1838 company founded by William Howe to make and market his patented truss. In 1862 Richard Fenner Hawkins joined the firm, then known as Harris, Briggs and Co. In the same year he married a niece of William Howe, solidifying his position in the company because the Howes still held some interest in it. In 1867 Hawkins became a partner; several more managing partnerships formed and dissolved over the next ten years until Hawkins assumed sole control in 1877, renaming the company R.F. Hawkins Iron Works. By that time the Springfield shops also produced boilers, standpipes, building materials, and railroad equipment, and the principal market area had broadened to include the Midwest and Canada. Perhaps as a means to enhance competitiveness in the northern markets, Hawkins set up Vermont Construction Co. at St. Albans in 1889. To judge from directory listings, the Vermont subsidiary appears only to have participated in the bridge-building portion of Hawkins' business. Vermont Construction changed its name to New England Bridge Works in 1901, perhaps reflecting a change in ownership. Due to the altered competitive situation after the formation of American Bridge Co. in 1900, and the real limitations of the sparsely settled northern market, New England Construction went into decline and by the 1920s was out of business as a bridge-builder.

Only two bridges in this study are known to have been built by Vermont Construction; with dates of 1889 and 1900, they represent the endpoints in time of the firm's activity under that name. Some of the spans for which no maker is known may represent the work of Vermont Construction, but even so, it appears that the company did not figure prominently in the construction of bridges in its home state.

References: Darnell, Directory, 25-26; "R.F. Hawkins Iron Works," Progressive Springfield 1, no. 2 (January 1891): 89-90; Hawkins obituary, Springfield Daily Republican, March 6, 1913; Vermont State Directory and Gazetteer, 1899-1901.

HARRY LESLIE WALKER

A New York-based architect, Walker was responsible for the design of the "Marble Bridge" in Proctor. It is his only known bridge work. Walker is best known for his participation on the team that designed the first public housing project in New York City, the Williamsburg Houses on Bushwick Avenue in Brooklyn, which went up in 1937.

References: Norval White and Elliot Willensky, A.I.A. Guide to New York City, revised edition (New York: Collier Books, 1978), 467.

J.R. WORCESTER AND COMPANY

Joseph R. Worcester worked as chief engineer for Boston Bridge Works in the late 19th century, before opening his own civil-engineering consulting firm in the same city. His prominent commissions included the Quincy Market cold-storage facility and the Louis Prang Co. factory. Worcester also designed the recently demolished 1905 arched steel bridge across the Connecticut River at Bellows Falls. The only example of his work in this survey is another steel arch over the Connecticut, the 1928 bridge at Wells River. The fabricator was Boston Bridge Works, Worcester's erstwhile employer.

References: Darnell, Directory, 76; Boston City Directory, 1895-1925; Henry G. Tyrrell, History of Bridge Engineering (Chicago: by the author, 1911), 354.

KNOWN BRIDGE FABRICATORS, CONTRACTORS, AND DESIGNERS

FABRICATORS

American Bridge Company
American Bridge Company of New York
Berlin Construction Company
Berlin Iron Bridge Company
Bethlehem Steel Company
Boston Bridge Works
Canton Bridge Company
Groton Bridge and Manufacturing Company
Groton Bridge Company
Henry L. Norton
Lackawanna Bridge Works Corporation
McClintic-Marshall Company
Palmer Steel Company
Penn Bridge Company of America
Pittsburgh-DesMoines Steel Company
Standard Engineering and Contracting Company
Vermont Construction Company

CONTRACTORS

M. J. Burrington, Jr.
Bryon, Forman & Riggs
J. E. Cashman, Incorporated
H. P. Cummings Construction Company
J. E. Flood & J. D. Sherrill
James Otis Follett
Gordon & Sutton (North Adams, Massachusetts)
Guild & Douglas (Springfield, Vermont)
J. A. Greenleaf Company (Auburn, Maine)
Hagan-Thibodeau Construction Company
H. L. Hauser Building Company
C. I. Hosmer
Hoyt Construction Company
Kittridge Bridge Company
A. B. Lane
O. W. Miller
D. J. Morrison
C. F. Newton Construction Company
Gerald B. Owens
Eugene A. Simpson
George H. Stebbins
United Construction Company

DESIGNERS

T. F. Chappell & E. L. Grimes
D. C. Linsley
John W. Storrs/Storrs & Storrs
J. R. Worcester
Harry L. Walker
McIntosh & Crandall

F. Associated Property Types

I. Name of Property Type METAL TRUSS BRIDGE

. Description

Entire text on continuation sheets.

III. Significance

Entire text on continuation sheets.

IV. Registration Requirements

Entire text on continuation sheets.

[X] See continuation sheet

[x] See continuation sheet for additional property types

I. Name of Property Type: METAL TRUSS BRIDGES

II. Description

In the first half of the 19th century, timber and stone dominated bridge building in Vermont. In the late 1860s, iron works began supplying prefabricated cast and wrought iron truss members to be used with pin connections; pneumatic riveted construction had not yet been perfected. Railroad companies built the first iron bridges, typically using wrought iron for the tension members and cast iron for the compression members. The first all wrought-iron bridge in the United States was constructed in 1859. Two decades later, after several bridge failures, cast iron proved to be unsuitable, and was phased out of bridge construction. The first all steel bridge went up in 1879 on the Chicago and Alton Railway. By 1895, the use of steel and pneumatic field riveting had been almost universally adopted.

In the survey, "Historic Metal Truss and Masonry Arch Bridges in Vermont," completed for the Vermont Division for Historic Preservation, approximately 75% of the 235 bridges surveyed are metal trusses. Of that number, only four bridges are wrought iron, making them an extremely rare and valuable resource in the state of Vermont. Their scarcity is due to the significant number of bridges lost throughout the state in the 1927 flood, and the exclusive use of steel for truss bridges during reconstruction after the flood. While no cast iron bridges survive in Vermont, the four wrought iron bridges date from c.1870 to 1896.

While many of the metal truss bridges found throughout Vermont are intact, some have suffered deterioration over the years as a result of exposure to corrosive road salt and pollution, extreme temperature changes, stress due to modern traffic loads, and lack of maintenance. One of the characteristics that made metal truss bridges so popular throughout Vermont was that they required little maintenance. However, many have not received the cyclical maintenance that is required to prolong the life of a bridge. That, in combination with increased traffic loads, has resulted in the need for structural reinforcement in a number of cases.

Metal truss bridges consist of one or a series of spans constructed from prefabricated members, usually on the site. The members vary in size and strength necessary for each particular bridge. Many pieces of iron or steel are

interconnected in a series of triangles or panels to form the bridge. Each member of the structure, depending on its position, is put in either tension or compression. Bridges are identified not by their length or number of panels, but by their configuration of tension and compression members, which includes the shape of the top and bottom chords, and the placement of vertical and diagonal members.

There are a variety of truss bridges, each with their own particular characteristics. They all, however, share some common parts. Each bridge has a floor system, often made up of a combination of plate-girder floor beams, rolled I-beams, cross-bracing, and steel-grill or concrete floor. The actual floor of the system is designed to be replaced as is needed over time, without disturbing the structural members of the bridge. The bottom chord usually consists of a box girder or channels with stay plates. Verticals and diagonals vary greatly from bridge to bridge, often utilizing paired angles, paired T-sections, I-beams, and paired channels, usually braced further by lattice bars. The top chord often consists of a box girder formed of plates and angles with a latticed underside. Additional bracing varies from latticed girder struts and bars to plate-girder struts and crossed or paired angles. Where present, railings and sidewalks vary greatly. Virtually all the Vermont bridges constructed before the 1927 flood have built-up members in various combinations of plates, channels and angles connected with rivets. The post-flood trusses used this technique for their top and bottom chords, but vertical and diagonal members between the chords are usually rolled I-beams that required no assembly.

All the different forms of truss bridges are one of three basic types: a through truss, pony truss, or deck truss. The through truss, designed to withstand the heaviest traffic loads which are carried at or near the level of the bottom chord, has lateral bracing between the top chords. When in use, the vehicle passes through the structure, thus the name. A pony truss is designed to carry lighter vehicular traffic at or near the level of the bottom chord but has no lateral bracing between the top chords. The deck truss carries its traffic load at or near the level of the top cord, with vehicles passing over the structural members of the bridge. After the 1927 flood and the standardization of steel members, bridges under 100' in length were usually Warren pony trusses. Most of the bridges featured a straight top chord parallel to the bottom chord, except

where heavy traffic called for a curved, or polygonal, top chord, which is stronger. For bridges between 100' and 160' in length, the standard was a Pratt through truss, although some overlap existed with the Warren pony trusses on the lower end. The Parker through truss, the polygonal top chord variant of the Pratt truss, was used above 160'.

The three basic types of metal trusses are typically one of two basic forms that date back to the 1840s: the Pratt and the Warren. These forms were used throughout the century, and because they adapted well to standardization of members, were built well into the 20th century. The last half of the 19th century was a time of experimentation and many different trusses were developed. Often these new forms were variations on the Pratt and the Warren trusses. Eventually the Pratt and the Warren proved their versatility and desirability through adaptability to a specific site, ease of construction, durability, and greater economy in materials.

Pratt Truss

The Pratt truss, patented in 1844 by Thomas and Caleb Pratt, offered simplified fabrication and construction because it used a limited number of different members in its webs, and the distribution of stresses could be calculated through mathematical analysis. The Pratt truss is distinguished by parallel chords with vertical members acting in compression and diagonal members acting in tension, design features that reduced the length of compression members to help prevent them from buckling. The span of the Pratt truss ranges from 25' to 150', with the pony truss used for the shorter spans and the through truss for the longer spans.

In Vermont, the Pratt was used in the construction of through and pony truss bridges. Typically, the top chord of a Pratt through truss is a box girder with a latticed underside. The bottom chord is usually made up of paired angles connected with a continuous top plate or stay plates, or two channels with top and bottom stay plates. Verticals and diagonals consist of rolled I-beams or paired angles, while top, sway and portal bracing varies greatly from bridge to bridge. The floor system consists of I-section floor beams and stringers with a concrete slab deck. The Pratt pony truss is very similar in construction but structurally more simple because of its shorter span and lighter traffic loads.

The Pratt configuration of compression and tension members

were utilized in a small number of bridges that continued to be built with the same structural members, but altered the shape of the top or bottom chords, or added short lengths of bracing (sub-struts). Those found in Vermont include the Baltimore (Petit) through truss with spans between 250' and 600', and the Lenticular (Parabolic) pony truss with spans between 150' and 400'. The Baltimore truss dates from the 1870s when engineers employed by the Baltimore and Ohio Railroad designed sub-struts and sub-ties to stiffen the Pratt truss in an attempt to maximize load capacity and support the ever increasing size and weight of their locomotives and freight. Like the Pratt, the Baltimore has parallel chords with the added structural members found in the diagonal webbing. The Lenticular truss is a Pratt with both the top and bottom chords parabolically curved over their entire length. Perhaps the most handsome and visually striking of all truss bridges, its name was derived from the particular lens shape it creates. It appeared in Europe in the 1850s, and by 1878 had made its way into American bridge construction. Although visually and economically attractive, its dramatic shape drove fabrication cost up, which soon ended its popularity.

Parker Truss

In the late 19th century, C. H. Parker of Boston designed a truss using the same structural members as the Pratt but with a curved top chord, creating a pattern that found broad application, and became known as the Parker truss. Because of its arched top chord, the bridge is stronger than a regular Pratt truss while using the same amount of material. Because of its added strength, the Parker covered spans up to 200' as compared to the 150' covered by the Pratt. The Parker, however, had a higher production cost because uniformity of the curved top chord was difficult to achieve.

A particular type of Parker is the camelback truss in which a segmented top chord is formed with five slopes. The camelback design was well accepted and widely used because its design allowed for greater standardization of its members, better stress distribution, and spans of up to 300'. Its cost and ease of construction made it especially popular for long spans that were required to carry heavier loads. Both the Parker and the camelback are found in Vermont as through truss and pony truss bridges.

Warren Truss

The other important truss is the Warren truss, patented by two British engineers in 1848, which was widely accepted by bridge engineers in the United States. Its simple, compact design with parallel top and bottom chords was extremely popular, and it continues to be used by bridge engineers today. Originally, in the 19th and early 20th centuries, a Warren truss was made up of diagonals alternately placed in compression or tension, giving the appearance of a series of triangles. Quite often, the diagonals serving as tension members were thin eyebars. Shortly after the turn of this century it became standard practice to use stiff, heavy diagonal members exclusively. Many Warren trusses also employ stiff vertical members, or increase the number of diagonals by overlapping them, both of which increase the structure's strength and load carrying capacity. The span of the Warren truss ranges from 50' to 400', with the through truss used for the longer spans and the pony truss used for the shorter spans. Like the Pratt, the Warren truss limited the number of different members in its webs and, because of its simple structure, stress distribution could be easily calculated.

In Vermont, the Warren was used in the construction of through and pony truss bridges. Typically, the top chord of a Warren through truss is a box girder with a latticed underside. The bottom chord is usually made up of a box girder or I-section angles, both with stay plates. Verticals and diagonals consist of rolled I-beams, paired angles, or I-section lattice girders, while top, sway, and portal bracing varies greatly from bridge to bridge. The floor system consists of plate-girder floor beams, or I-beam stringers and cross beams, with a concrete slab deck. The Warren pony truss is structurally more simple because of its shorter spans and lighter traffic loads. The major difference appears in the floor system with pony trusses, often having a wooden plank deck.

Like the Pratt truss, the basic Warren truss was adapted to support heavier loads and longer spans by using a polygonal top chord in place of the flat chord. Those found in Vermont are of the pony truss type, and are called Warren polygonal pony trusses. This type of pony truss typically is used over a short span where traffic loads are increased.

III. Significance

The bridges included in this type are found throughout the state of Vermont. They are historically significant under National Register Criterion A for contribution to the broad patterns of our transportation history, and architecturally significant under National Register Criterion C for embodying the types, forms, and methods of engineering and construction as associated with bridge building in Vermont in the 19th and 20th centuries.

The bridges include a number of truss types, from the simple single span deck truss to the multi-span through truss, all of which reflect the development and engineering advancements made in bridge building over the last 150 years. Located in rural areas, towns, and cities, the bridges are an important part of the Vermont landscape. Because they offered the latest technology in bridge building at an affordable price, and expanded transportation routes within individual communities, metal trusses are significant at the local level. These bridges have significance at the state level because they helped to link a growing state road system which in turn increased inter-regional transport, travel, trade and commerce.

Wooden trusses and covered bridges led to the truss bridges of the late 19th and early 20th centuries when new engineering and manufacturing technology introduced the use of prefabricated iron and steel members into bridge building. Manufacturers were able to produce bridge components that could carry increasingly heavy loads, meet the specific requirements of each site, and stand up to the elements with minimal upkeep.

The types of bridges found in Vermont were influenced by engineers from England as early as the 1840s, as well as engineers employed by the railroads and bridge companies later in the century. Continually evolving technology, such as the ability to calculate stress on individual bridge members, the improvement of pre-fabrication and standardization techniques, and construction methods that allowed bridges to be built more easily, are represented in Vermont's truss bridges. Much of this new technology was brought to all parts of the state by contractors representing fabricators or their own firms. Due to Vermont's remote location, the distance from bridge manufacturing centers, the mountainous terrain, and inadequate roads, companies

from New England and New York had the most impact on bridge construction in the state. Among these were Connecticut's Berlin Iron Bridge Company, New York's Groton Bridge and Manufacturing Company, and the American Bridge Company, initially owned by J. P. Morgan and, later, by U.S. Steel. Designers, fabricators, and contractors that are known to have worked in Vermont are listed at the end of Section E.

Because of their versatility in configuration and member size, truss bridges were adaptable to a wide variety of site requirements. This versatility also made them affordable. As the 19th century progressed, more modifications were made to already existing designs, which enabled bridges to span greater distances and carry heavier loads. Methods of assembly progressed from the pinned and bolted members that were assembled by the manufacturer, which limited the distance the large bridge pieces could be shipped, to riveted construction of the entire bridge on the job site.

The state and federal government programs that developed in the late-19th and early-20th centuries, involving construction funding and the regulation of roads, greatly increased the number of bridges in Vermont and drove truss bridges into the 20th century. With the flood of 1927 and the loss of over 1200 bridges statewide, Vermont was pushed to the forefront of bridge construction. Over 1600 bridges, many of which were steel trusses, went up between 1928 and 1930. Because such a great number of bridges had to be replaced as quickly as possible, the latest engineering technology was employed in the standardization of truss members. This replacement program was a massive undertaking, both in terms of logistics and manpower, and one in which Vermont served as classroom for the rest of the nation. After the flood and the completion of the reconstruction program, bridges continued to be built utilizing the established designs and standardization practices, many of which continue to be used today.

IV. Registration Requirements

The physical characteristics and design integrity of each form of metal truss bridge is as stated in the property type description. Many metal truss bridges survive in Vermont, dating from as early as 1870, with the majority built in the 20th century before 1940. Specifically, the four wrought iron bridges that survive were constructed between c.1870 and 1896. Steel trusses date from 1892 to 1939.

In general, properties meeting registration requirements should have been built before 1940 and be intact with an identifiable truss system, the majority of which should be original members. In the case of multiple spans, at least one span of the original structure must remain with an identifiable truss system. The truss system should be capable of functioning, with or without structural reinforcement, but need not be in use for carrying traffic. Additions such as sidewalks, guard rails, replaced decking, and new abutments are acceptable as long the truss system is in place. A bridge that is eligible only under Criterion A for its historical significance should retain its integrity of location and setting. Bridges eligible under Criterion C for engineering significance need not be in their original setting, but should be in a location appropriate for the property type.

I. Name of Property Type: MASONRY BRIDGES

II. Description

The use of stone for bridge building took advantage of the vast quantities of stone indigenous to Vermont. Although the stone was plentiful, it demanded more time to work for proper assembly than did the pre-fabricated metal truss bridges, and the required skilled craftsmen were not always present. As a result of limited expertise, masonry bridges are far less common than the early timber bridges or the metal truss bridges that replaced them. Due to the limited number of bridge masons working in relatively small areas in Vermont, masonry bridges appear in clusters, further indicating that their construction depended on the presence of skilled local craftsmen.

Masonry bridges were built throughout the 19th century and into the 20th century, but with less frequency after the 1860s when metal truss bridges were widely accepted. Lower costs in fabrication and construction, as well as government funding of many of the projects beginning in the early 20th century, ensured the dominance of the metal truss. Consequently, many of the masonry bridges constructed in the late-19th and early-20th centuries were built by towns or funded by wealthy private citizens as a monument to their town or family. These bridges, because of their location in town centers or their function as a commemorative monument to a particular family or individual, took on a more formal appearance in contrast to the rugged appearance of the masonry bridges found in the countryside. The town center bridges were built more with a sense of permanence as reflected in the finished surfaces of the exposed stones, decorative railings, ornamentation, and street lights.

Masonry bridges consist of one or a series of stone arches constructed of rubble, ashlar, or a combination of both. The ashlar can be found in a number of stone faces and cuts, including rock-faced and rough-cut, coursed or random ashlar. Fieldstone, limestone and granite are the most commonly used stones, but marble, gneiss and brick appear on some bridges as part of the structure or as ornamentation. Typically, each arch is round, semicircular or segmented, or on rare occasions, horseshoe-shaped.

The rugged masonry bridges built by country artisans are usually smaller in size and are constructed of fieldstone or

granite, laid whole or rough-cut into slabs, and mortared into irregular courses. The arch itself is built with coursed stone to support the structure, while a ring of split stones typically forms the voussoirs. The spandrels, and wing walls where present, often consist of uncoursed dry rubble. Gravel or pavement overlays the whole structure to form the road surface.

Masonry bridges located in areas of heavier population have a more formal, finished appearance, and are typically much larger than the bridges built by country artisans. The voussoirs are usually cut stones, often projecting slightly beyond the vertical plane of the surrounding spandrels. Spandrels and piers are coursed, as is the stone or brick that forms the arch of the bridge. Typically, coursed stone or concrete form the bridge embankments. Many of these masonry bridges are ornamented with keystones, parapets, stone rails, and carved stone tablets giving information such as the construction date of the bridge and names of the builder, contractor, and engineer. Unlike the truss bridges, very few of these bridges incorporate sidewalks into their designs.

Generally, the condition of masonry bridges depends on the amount of maintenance and use each span has received over the years. All masonry spans suffer the effects, to varying degrees, of exposure to road salt, pollution, extreme temperature changes, and increased traffic loads. The condition of each individual bridge reflects its maintenance schedule, if any, as well as the traffic carried over the span. With the increased weight of vehicles, some bridges that were not designed to support the modern-day loads and vibrations have deteriorated.

Monumental spans typically were designed by engineers with permanence in mind. Their stones were cut with precision to create a tight fit within a particular pattern or course. With the exception of the barrel of the arch, bridges built by country artisans were not designed and constructed with the same precision, typically using random courses of stacked stones and dry rubble infill. While no less significant for their design, these bridges have deteriorated more over the years due to the settling, shifting and washing away of stone.

III. Significance

The bridges included in this type are found throughout the state of Vermont. They are historically significant under National Register Criterion A for contribution to the broad patterns of our transportation history, and architecturally significant under National Register Criterion C for embodying the styles, forms, and methods of engineering and construction as associated with bridge building in Vermont in the 19th and 20th centuries.

Masonry bridges are locally significant for a number of reasons. In addition to expanding transportation routes in rural areas and communities, these bridges reflect the construction skills of local stone masons. In many rural areas masonry bridges are found in clusters, often having the same builder. Masonry bridges in more populated areas represent the pride and permanence of the family or community that built the bridge. These bridges are significant at the state level because they helped to link a growing state road system which in turn increased inter-regional transport, travel, trade and commerce.

The masonry bridges range in size from a single arch crossing a small stream to multiple arches spanning a large river. They represent the vernacular construction styles and techniques of the country artisans, as well as the bridge builders and contractors of the monumental and commemorative masonry bridges found in Vermont's larger towns.

Unlike truss bridges, the appearance of a masonry bridge is most influenced by its location. Bridges found in the rural areas are rugged in appearance, most often using fieldstone and rubble laid randomly, except for the ring of the arch, where the stones had to be split and fitted to assure the arches stability. These bridges were most often constructed by country artisans, reflecting local craftsmanship and materials. One of Vermont's most celebrated bridge masons was James Otis Follett, a farmer from Townshend in Windham County. Follett, who was apparently self-taught, built as many as forty bridges in nearby Vermont and New Hampshire towns, primarily between 1890 and 1910.

Masonry bridges constructed by towns, and commemorative, monumental spans built by wealthy individuals had a more permanent appearance and reflected a higher level of

craftsmanship than the country bridges. They were typically designed by architects or engineers. Masonry arches in town centers were more formal, with finished surfaces for all the exposed stones, and designs that incorporated elements such as sidewalks, decorative railings, parapets, and street lights.

By the turn of the 20th century the state government began to oversee construction and regulate the use of roads and bridges. Because masonry bridges were labor intensive, more expensive to build, and required skilled craftsmen that were not always readily available, the government encouraged the construction of truss and concrete bridges by instituting programs that made these bridge types more widely used. Programs included structural engineering services for truss bridges and free plans for concrete bridges. In 1915, the state legislature established a bridge fund that was used to help towns pay for bridge construction. Masonry bridges were not funded because they were too expensive. As a result of limited construction after 1900, and the number of bridges lost during the flood, the masonry bridges that survive in Vermont today are very rare resources.

IV. Registration Requirements

The physical characteristics and design integrity of masonry bridges is as stated in the property type description. A limited number of masonry bridges survive in Vermont, dating from the early-19th to the early-20th centuries.

In general, to qualify for registration the bridges should have been built before 1940, and the original core and design features should be intact. The bridges should be capable of functioning, but need not be in use for carrying traffic. The bridges may have had structural reinforcement since they were originally constructed. Where a bridge has been reinforced or widened, one side of the original structure should be intact. A portion of the original structure, such as the spandrels or the barrel of the arch, should be visible and intact when concrete reinforcement is used extensively. Additions such as sidewalks, guard rails, replaced decking, and new abutments do not compromise integrity and are acceptable. A bridge that is eligible only under Criterion A for its historical significance should retain its integrity of location and setting. Bridges eligible under Criterion C for engineering significance need not be in their original setting, but should be in a location appropriate for the property type. Due to the nature of construction and materials, it is unlikely that bridges in this property type will have been moved to another site.

I. Name of Property Type: CONCRETE BRIDGES

II. Description

The use of concrete for bridge construction began in the closing decades of the 19th century. As a result of technological improvements, including the use of hydraulic and Portland cement, reinforced concrete, and the fact that concrete required less maintenance while providing greater design flexibility than steel, concrete spans moved to the forefront of bridge construction, ultimately dominating the 20th-century highway system.

Steel reinforcements increased the use of concrete, giving it widespread application in the 20th century. At the end of the 19th century, concrete was reinforced in one of two ways. Named for its Austrian inventor, the Melan technique embedded steel I-beams in the cast concrete. This method was most widely used into the early-20th century. Because the Melan technique had I-beams carrying the load, the concrete was used more for appearance than for structural support. The other method used was the Ransome technique, which placed steel bars only in areas of tension. As more advances were made in the technology of reinforced concrete, the Ransome method was more widely embraced by engineers, and today, has been adapted to modern concrete bridge construction.

In Vermont, concrete bridges went up in the first decade of the 20th century after the newly formed State Highway Commission began appropriating funds and supervising the construction of bridges. The Commission preferred concrete over stone because it was cheaper, and the materials and labor to construct the bridges were readily available throughout the state. By 1915, plans for concrete bridges were available from the Commission free of charge to any town that wanted them. Many of the the spans found throughout Vermont were erected according to the state's specifications, which like truss bridges, brought standardization to concrete bridges.

Like stone, concrete has compressive strength but very little tensile strength. Because of compressive strength, masonry bridges proved to be very stable, durable structures, and many early concrete bridges were patterned after their designs. Concrete girder and I-beam bridges were the most common type of bridge constructed before 1940. The

girders supported the bridge deck, which carried the road, between piers or abutments. Unlike the modern steel-girder bridges, the beams were made out of concrete. Cost advantages in materials and construction time, as compared to the labor intensive masonry bridges, made concrete more affordable to towns, even when no state money was involved.

Concrete bridges typically have round or segmental arches and range in size from a simple arch over a small stream, to a series of arches spanning a large river or gorge. Like masonry bridges, the simplest bridges are located in small towns and rural areas. Most are purely functional, having no ornamentation. Many were built by the local labor force using plans supplied by the state. The larger concrete spans also used the state plans, but often were designed with some decorative detailing. Like the deck truss and masonry bridges, concrete bridges carry their traffic loads at the top of the structure, with vehicles passing over the the structural members of the bridge.

The most basic and common form is the closed spandrel, in which the spandrel is solid concrete. In Vermont, this form varies greatly in style, escaping complete repetition from site to site. Many incorporate decorative details such as pilasters, parapets, recessed panels, plaques, coping, string courses, pieces of stone, and stanchions with finials. Some towns chose to use a concrete bridge as a commemorative structure as had been done previously with the masonry spans. The concrete was often finished to imitate stone with such detailing as inscribed lines creating voussoirs of the arch and raised central tablets to resemble keystones.

Far less common than the closed spandrel is the open spandrel concrete bridge, which is typically used on long spans over deep gorges. The open spandrel differs in that much of the space is left open between the ring of the arch and the floor of the roadway. This form offers substantial economy of material in long crossings while having great potential for creative design. Often, the open spandrel forms a decorative appearance with its rhythmic vertical supports, adding to its desirability. Some early bridges had decorative capitals on columns, or used arcades to support the deck. During the early 20th century engineers began to simplify the forms, alluding to the coming forms of the modern highway bridges. Rectangular columns replaced arcades, and the main arch was reduced to paired arch ribs.

Construction of both forms of spandrels begins in the same way. After the abutments and piers have been cast, forms are built for the arch itself. For the closed spandrel, the space between the arch and the deck is filled in with concrete or, in the early years, with earth. In open spandrel bridges, the deck is supported by columns or arcades that are built on top of the main arch.

Like metal truss and masonry bridges, the condition of concrete bridges in Vermont has been effected by exposure to pollution, road salt, extreme changes in temperature, and increased traffic loads, as well as a lack of cyclical maintenance in many cases. The most common cause of concrete deterioration is chloride contamination, which causes the concrete to spall and crack, and results in the need for structural reinforcement.

III. Significance

The bridges included in this type are found throughout the state of Vermont. They are historically significant under National Register Criterion A for contribution to the broad patterns of our transportation history, and architecturally significant under National Register Criterion C for embodying the types, forms, and methods of engineering and construction as associated with bridge building in Vermont in the 19th and 20th centuries.

Historically, bridges linked roads or railways together over gorges, streams, and rivers to contribute to an interregional transportation system, not only in Vermont, but across the nation. The concrete bridges found in Vermont were influenced by designs from Europe, as well as several early structures built in the United States. Continually evolving technology, such as the development of stronger cements and steel reinforced concrete, are advancements that are represented in Vermont's concrete bridges. Because of the relative ease of construction and lower cost, as compared to masonry bridges, and the availability of construction plans from the state, these bridges can be found statewide.

Concrete was especially useful to small towns in that they could construct a relatively inexpensive, utilitarian bridge wherever needed. They benefitted most from the distribution of construction plans, which began after 1915 in Vermont. Although this procedure standardized the basic design, concrete bridges were individualized and vary in appearance from site to site.

The bridges include two basic forms, the open and closed spandrel. While the closed spandrel has a number of applications, the open spandrel is used for very long spans, often over deep gorges. Standardized plans and cost efficient construction, paralleled by development of the automobile and expansion of our road system, increased the use of concrete in the early 20th century. After the 1927 flood many bridges built during the reconstruction program were concrete. Early concrete bridges, along with truss bridges and technological advancements in the use of box girders, rigid frames, slabs, mushroom columns, and prestressed concrete have all led to the development of modern bridges that are part of our highway and secondary road systems found throughout the American landscape today.

IV. Registration Requirements

The physical characteristics and design integrity of concrete bridges is as stated in the property type description. The concrete bridges that survive in Vermont and that are eligible for the National Register were constructed between 1909 and 1940.

In general, bridges meeting registration requirements should have been built before 1940, and the original core and design features should be intact. The bridges should be capable of functioning, but need not be in use today for carrying traffic. The bridges may have had structural reinforcement since they were originally constructed. Where a bridge has been reinforced or widened, one side of the original structure should be intact; widened portions should be of similar construction and materials. A portion of the original structure, such as the spandrels or the barrel of the arch, should be visible and intact when concrete reinforcement is used extensively. Additions such as sidewalks, guard rails, replaced decking, and new abutments do not compromise integrity and are acceptable. A bridge that is eligible only under Criterion A for its historical significance should retain its integrity of location and setting. Bridges eligible under Criterion C for engineering significance need not be in their original setting, but should be in a location appropriate for the property type. Due to the nature of construction and materials, it is unlikely that bridges in this property type will have been moved to another site.

Summary of Identification and Evaluation Methods

The survey on which this Multiple Property Documentation Form was based was conducted in 1985 by Historic Resource Consultants for the Vermont Division for Historic Preservation. This comprehensive survey identified all metal truss, stone arch, and concrete arch bridges built before 1940 that are located on public roads in Vermont. The survey did not include bridges of limited engineering significance, such as plate-girder, I-beam, stone slab, and concrete beam and slab bridges. Wooden-truss covered bridges are not included because virtually all of them have already been listed in the National Register. Initial identification of bridges was made by using the Vermont Agency of Transportation Bridge Inventory System, which includes all of the state's highway bridges. Surveyors checked and photographed all bridges in the field, made detailed notes made on their construction, made measurements of most truss members (except where no access was possible), filled out detailed survey forms, and plotted their locations on USGS maps. Sources consulted for the research are listed in section H (Major Bibliographical References).

The historic context, "Metal Truss, Masonry, and Concrete Bridges in Vermont," was based on the survey report, "History of Bridge Building in Vermont," prepared for the bridge survey. The typology of property types (metal truss, masonry, and concrete bridges) was based upon the bridge construction material.

The standards for integrity were based on the National Register standards for assessing integrity. Information from the bridge survey, knowledge of the condition of existing properties, and information on the numbers of existing bridges of each property type was used to determine the degree to which allowances should be made for alteration and deterioration.

G. Summary of Identification and Evaluation Methods

Discuss the methods used in developing the multiple property listing.

☐ See continuation sheet

H. Major Bibliographical References

☒ See continuation sheet

Primary location of additional documentation:

- ☒ State historic preservation office
- ☒ Other State agency (Transportation)
- ☐ Federal agency
- ☐ Local government
- ☐ University
- ☐ Other

Specify repository: Agency of Transporation

I. Form Prepared By

name/title Heather Rudge

organization Division for Historic Preservation date December 15, 1989

street & number c/o Pavilion Office Building P.O. telephone (802) 828-3226

city or town Montpelier state Vermont zip code 05602

Most of the information in this Multiple Property Documentation form is based on the bridge survey conducted for the Vermont Division for Historic Preservation by Historic Resources Consultants of Hartford, Connecticut.

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